

A LINEAR AMPLIFIER UNIT FOR THE HF BAND TRANSCEIVER

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(Part 1)



Lorin Knight, MIEE, was born in 1922 and became interested in short-wave radio at the age of about 12. He obtained an AA licence shortly before the second world war, and had to wait until 1946 to get his G2DXK callsign. His main activity over the last 20 years or so has been on 21MHz ssb, always using home-built equipment. The earlier part of his professional career was spent with Murphy Radio, but for 30 years he held various technical and managerial posts with ICL. He is now retired and expects to be devoting much more time to amateur radio.

IN 1984 (*Rad Com* June-October) I described a homebrew QRP transceiver for the hf bands. This follow-up article describes a complementary linear amplifier unit which will give approximately 100W p.e.p. output when driven by the transceiver. It includes a preamplifier which enhances the receiver performance, particularly on the higher frequency bands—and it also includes power supplies to operate both the linear amplifier and the transceiver. A simplified block diagram is given in Fig 1.

Linear amplifier

The circuit of the linear amplifier itself is given in Fig 2. As shown, it is capable of operation on any band from 3.5 to 28MHz. Later it will be shown how it can be adapted for operation on 1.8MHz as well.

The design is somewhat unusual for these times in that it uses valves rather than transistors, but I believe that, for a power amplifier, valves are easier for the home constructor to handle. They are much more tolerant to accidental misuse, and they provide a much greater gain than transistors. With just one stage of valve amplification, an output of around 100W p.e.p. is obtained from 0.5W input. The specified valve type is the 6146B, but the 6146 or the 6146A could be used instead (with slightly less output).

The valves are operated in Class AB1 and are driven via the wideband transformer T101, which raises the peak value of the input signal from 7V to 49V. On the higher frequency bands it is essential to tune out the input capacitance of the valves in order to prevent excessive shunting of the transformer. It was consequently decided to have the switch S4 provide a shunt-tuned circuit for every band. The circuit shows eight tuned circuits covering all bands from 3.5 to 28MHz inclusive but, of course, it is only necessary to provide for those bands which are to be used. Miniature ferrite-

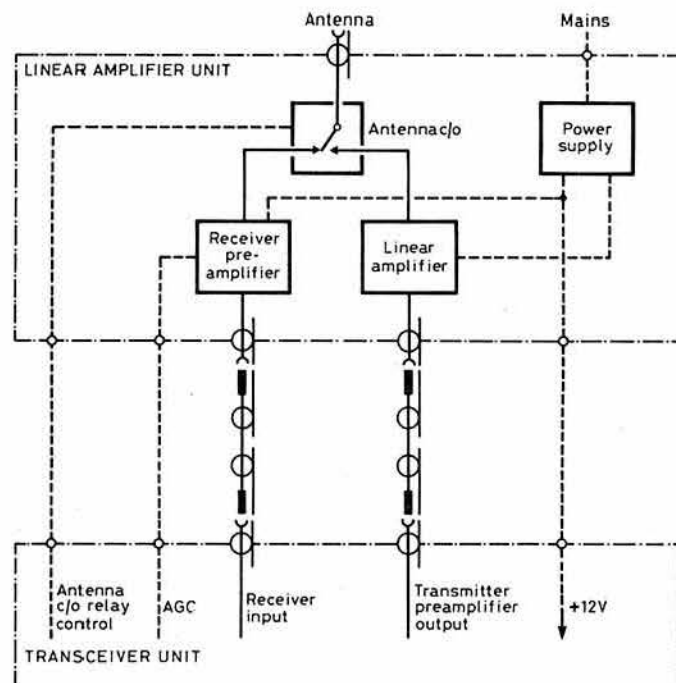


Fig 1. Block diagram of the linear amplifier unit

core receiver-type coils are not suitable for use here because the rf energy present would saturate the ferrite material. Consequently home-wound coils having iron dust cores are used.

The output circuit uses a conventional switched pi network but uses components which are a little easier to obtain (and a little less expensive) than those normally specified. For example, the TUNE capacitor C9 is not a special transmitting-type capacitor; it is a standard 365 + 365pF receiving-type capacitor, with the two sections in series to obtain an adequate air gap. The switch S5 is a small, readily-available Maka-Switch assembly which has proved quite adequate to withstand the rf voltages and currents encountered.

Neutralizing is done by the usual series capacitance method but, instead of C8 being a high voltage variable capacitor, it is an inexpensive disc capacitor and the neutralizing adjustment is done by the lower voltage trimmer capacitor C107.

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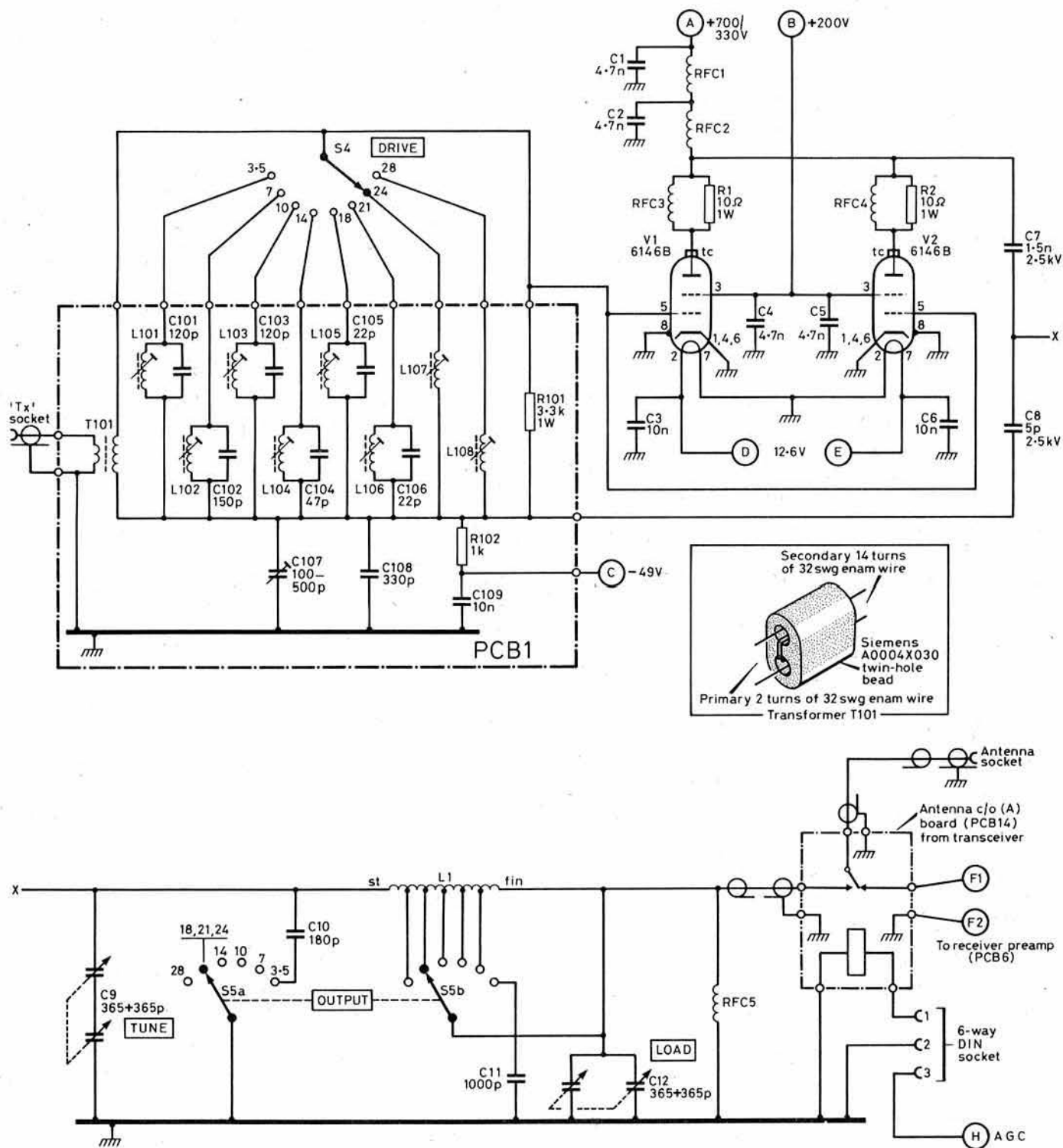


Fig 2. Circuit of the linear amplifier section. Components within dotted lines are on printed circuit boards

In most traditional designs the construction of the anode choke has been quite complex in order to avoid resonances in any of the amateur bands (and this was before the introduction of the 10, 18 and 24MHz bands!). In this design the anode choke RFC2 is a simple long thin coil. This succeeds in giving no resonance between 1.8 and 30MHz, but its inductance is on the low side (around 35 μ H). This means that an additional 50pF or so is needed to tune out its inductance on the 3.5MHz band (and an additional 200pF or so needed on 1.8MHz)—but this is not a very serious disadvantage. A similar choke is used for RFC5.

Compared with the sophisticated no-tuning circuitry of some modern commercial black boxes, it might seem rather clumsy to have to operate several switches to change bands. In practice, however, it is not usual to spend time hopping around from one band to another, and the

inconvenience is not very great. In return, there are some advantages. The tuned circuits attenuate the harmonics (and any other unwanted frequencies) thus making it much less important to use lowpass filters. The separate switches make the construction very much more simple than it would have been with just one multi-section switch.

Power supply

The circuit of the power supply section is given in Fig 3. The main ht supply is provided by the two bridge rectifier circuits D201-204 and D205-208, which are fed from the secondaries of the small toroidal transformers T2 and T3. The lower bridge circuit gives an output of around 330V dc, and the upper one (which uses a slightly different transformer) around 370V. Thus the ht is around 700V with both transformers switched in, and around

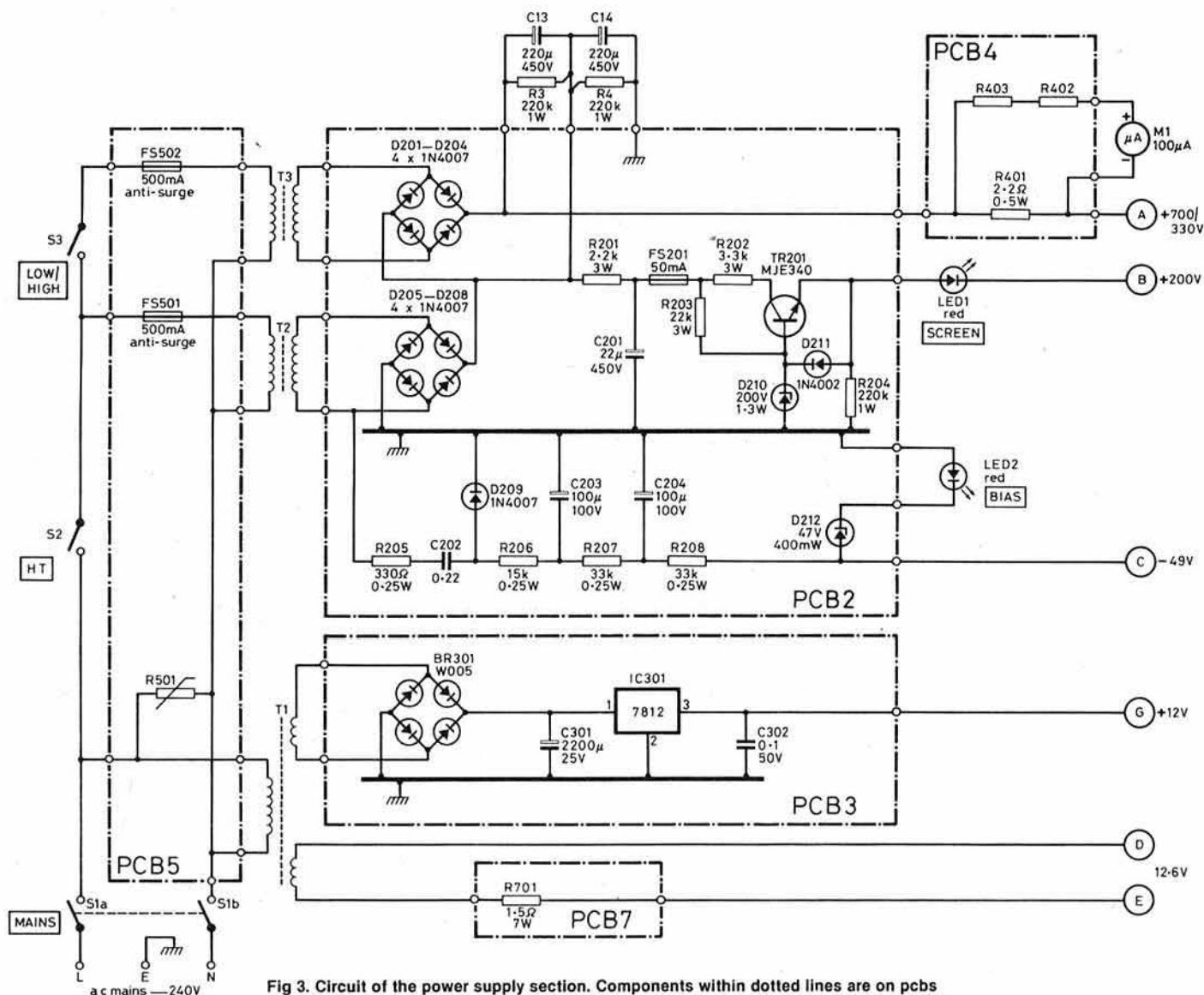


Fig 3. Circuit of the power supply section. Components within dotted lines are on pcbs

330V with only T2 switched in. The lower ht voltage is useful for testing or for operating at low power. Indeed, if the constructor wants to save money he could get by without T3 initially. The ht current is monitored by the meter M1, which has the added shunt circuit R401, R402, to make it read 300mA full scale. A 100μA meter is specified, but one of a different sensitivity can be used if the values of the three resistors are suitably modified.

The ht supply for the screens of the valves is obtained from the lower half of the ht supply, and is stabilized at 200V by the series transistor TR201 in conjunction with the 200V zener diode D210. The resistors R201 and R202 limit the voltage at the collector of TR201 (and hence its dissipation) when the screen current is high. The screen current is high (adequately if not precisely) by observing the brightness of LED1.

The bias supply is provided by the half-wave rectifier D209, which is capacitively fed from T2 secondary. The output is stabilized at 49V by the 47V zener diode D212 and the light-emitting diode LED2. The latter not only adds approximately 2V to the output voltage, it also indicates if the valves take any grid current. Under normal circumstances the current passing through D212 and LED2 is around 2mA. However, any grid current resulting from the valves being overdriven will add to this 2mA and produce a noticeable increase in the light output. (In order to obtain a reasonable level of brightness with a current of 2mA it is necessary to use a "high-brightness" led.)

A stabilized 12V supply for the transceiver unit is provided by the bridge rectifier BR301 and the voltage regulator IC301 operating off one 15V secondary of T1. The other 15V secondary, in conjunction with the dropper resistor R601, provides 12-6V ac for the heaters of the two 6146B valves. Each valve requires 6-3V at 1-125A, and their heaters are connected in

series. Note that if 6146 or 6146A valves are used these take a higher heater current and R601 will need to be 1Ω instead of 1-5Ω.

R501 is a voltage-dependent resistor specifically designed for suppressing high-voltage transients on the mains supply. This device is included to prevent any possible damage to the ht rectifier diodes.

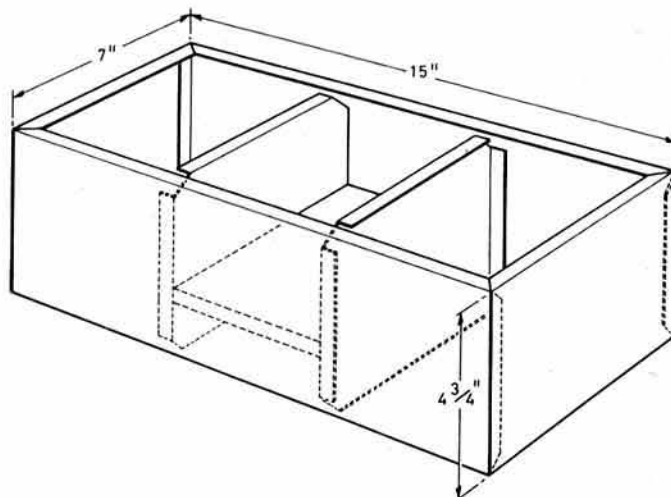


Fig 5. Basic form of the cabinet (lid removed)

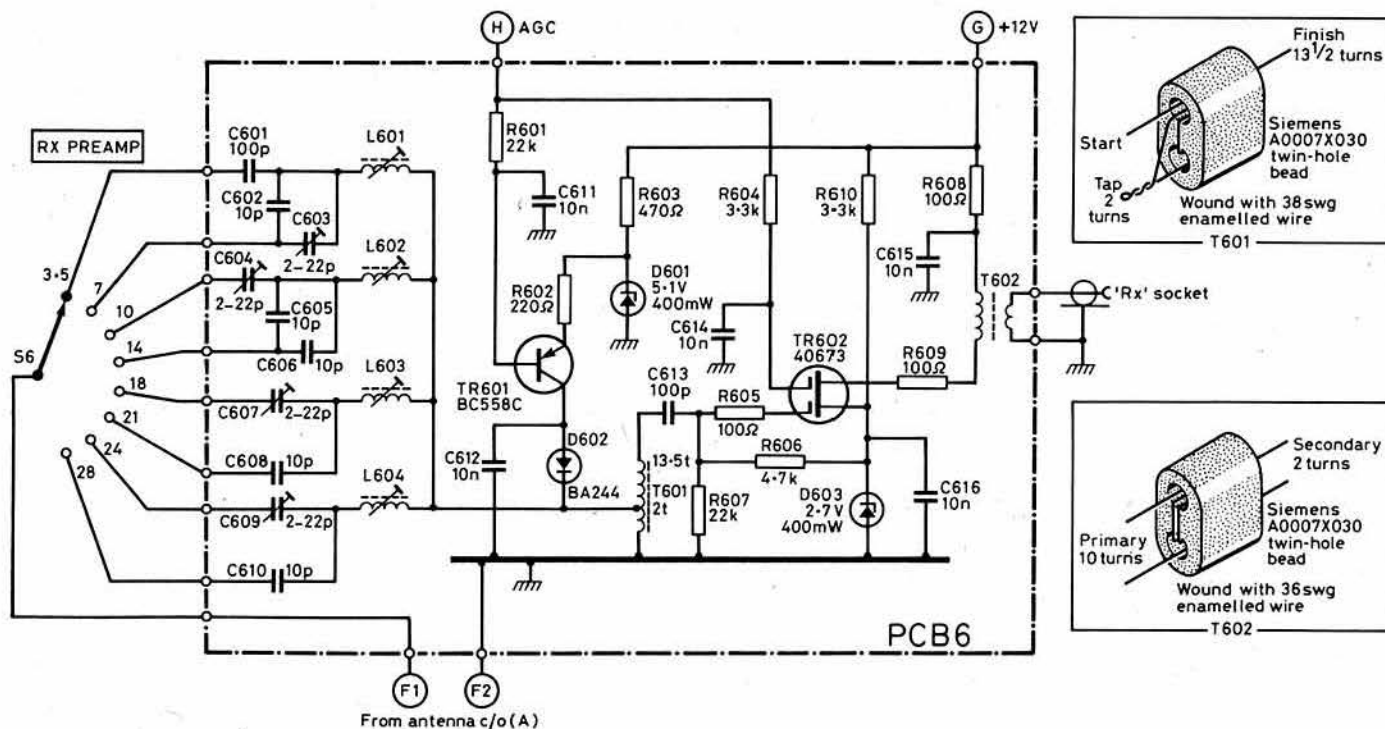


Fig 4. Circuit of the receiver preamplifier. Components within dotted lines are on pcbs. C605 should be in parallel with C604, not as shown

Receiver preamplifier

The circuit of this is given in Fig 4. The basic preamplifier consists of the fet TR602, which has at its input the wideband transformer T601, and at its output the wideband transformer T602. To give some rejection of unwanted frequencies, the switch S6 inserts a series-tuned circuit between the antenna and the input to T601. As shown, all bands from 3.5 to 28MHz are catered for, but the individual constructor can omit the coils and capacitors for those bands in which he is not interested.

The diode D602, in conjunction with the transistor TR601, acts as an rf attenuator which is controlled by the agc line. When receiving a very weak signal the agc line is at +5.6V and TR601 is cut off: no current flows through the diode which consequently has a high resistance. When the received signal is strong enough to drop the agc line to +4.6V, TR601 starts to conduct and the resistance of D602 starts to fall, shunting the input to TR602. With a very strong input signal the resistance of D602 can fall low enough to give around 40dB attenuation. Note that a special switching diode is specified. A general-purpose type such as the 1N4148 will not give such good attenuation.

Cabinet

As with the transceiver, the cabinet is made by bolting together a number of simple aluminium panels and chassis. Fig 5 shows the basic shape of the cabinet (with the lid removed) and Fig 6 gives details of the various constituent parts. The parts for my cabinet were made quite cheaply by H L Smith & Co Ltd, 287/289 Edgware Road, London W2. The two vertical screens were purchased as square-cornered chassis, and I cut off the corners. The initial intention was for the linear amplifier unit to have the same dimensions as the transceiver unit. In fact the original version of the linear amplifier unit was made that size, but it was a

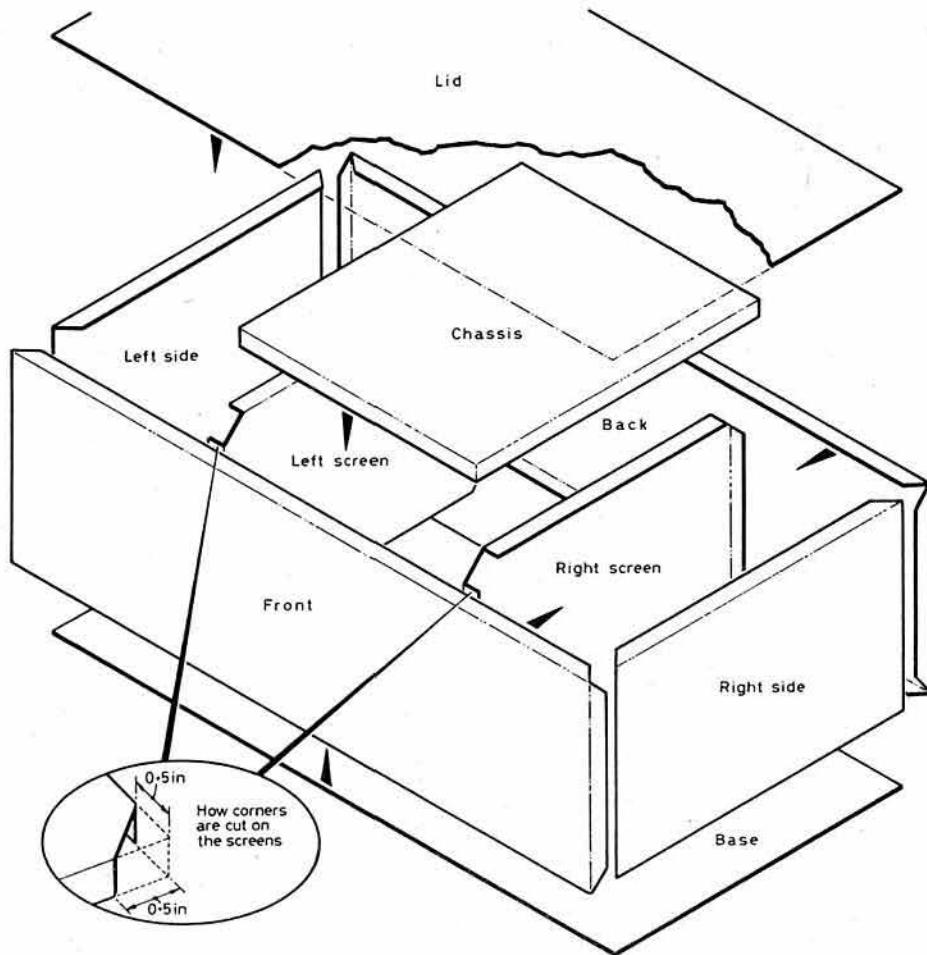


Fig 6. Component parts of the cabinet (made of 18swg aluminium). Base and lid: 15 by 6.875in. Front and back: 15 by 4.75in with 0.375in flanges. (Flanges have a 45° cut at each end.) Sides: 7 by 4.75in with 0.375in flanges on the longer sides. (Flanges have a 45° cut each end.) Screens: 6.937 by 4.75in with 0.375in flanges on each side. These are initially square-cornered chassis. The corners are then cut as shown in the inset. Chassis: 6.937 by 5in with a 0.375in flange on each side

very tight squeeze and, reluctantly, it was decided to make the final version slightly larger.

Fig 7 shows the view looking down onto the assembled unit and indicates the positions of the major components. Fig 8 shows the view with the unit turned upside down. The metalwork should be drilled as indicated in Figs 9 to 16 inclusive, and all the sections (except the lid and base) bolted together using M3 or 4BA bolts (preferably panel headed). When drilling the chassis (Fig 15) it is recommended that a template be made from a suitable piece of graph paper, which can then be pasted onto the chassis and used as a drilling guide.

Note that the screw marked "b" in the top left-hand corner of the front panel is used to hold the output coil L1, and, for aesthetic reasons, it is advisable to have this screw in position before spraying the cabinet. L1 should be wound on a 1.25in diameter former, which is about 2in long. The coil former can be one of the small cylindrical plastic containers such as are used for 35mm film, pills etc. The lid can be mounted behind the panel using a 0.625in high spacer (cut from an old fibre-tip pen) and the coil can be plugged into the lid later.

The next stage in the construction is to cover all the open holes with masking tape on the inside of the cabinet; to fix the lid and base, using self-

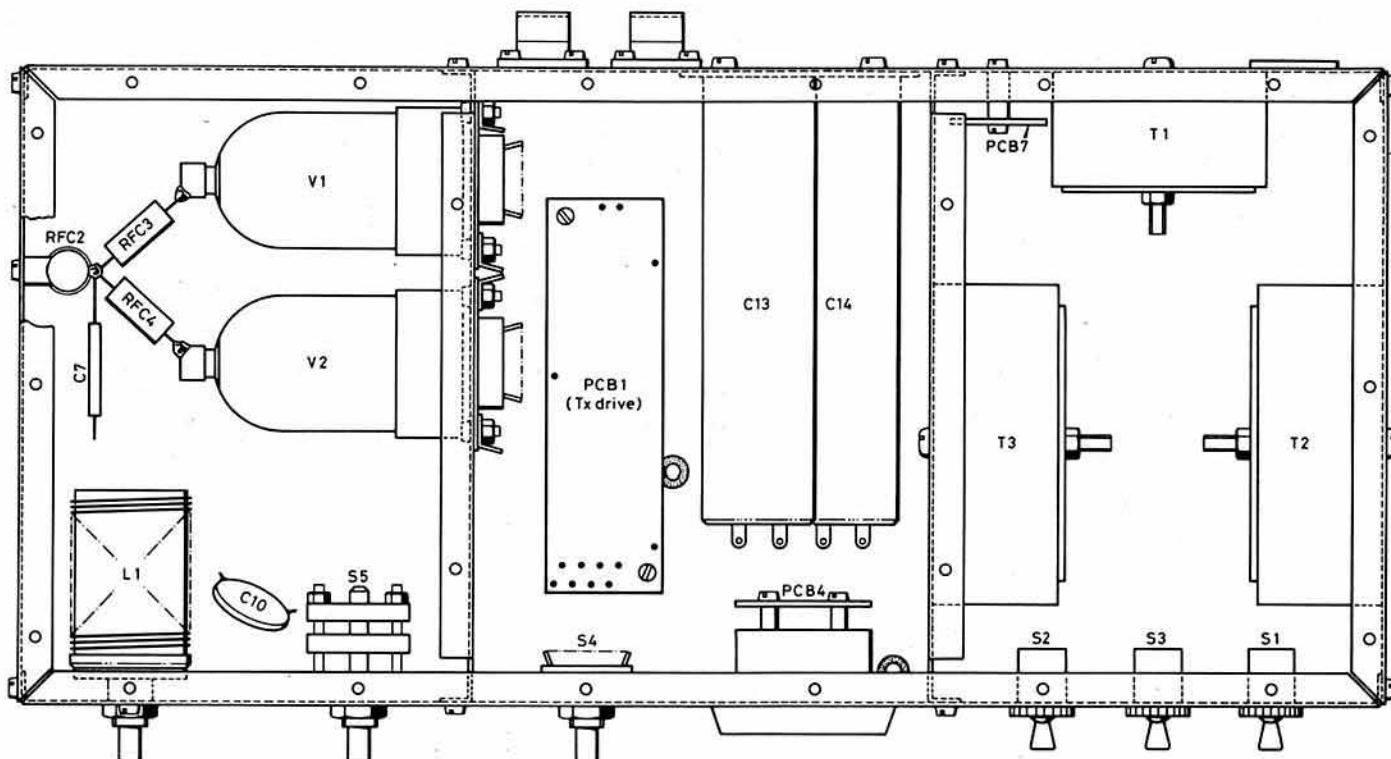


Fig 7. View looking down on the linear amplifier unit (with lid removed)

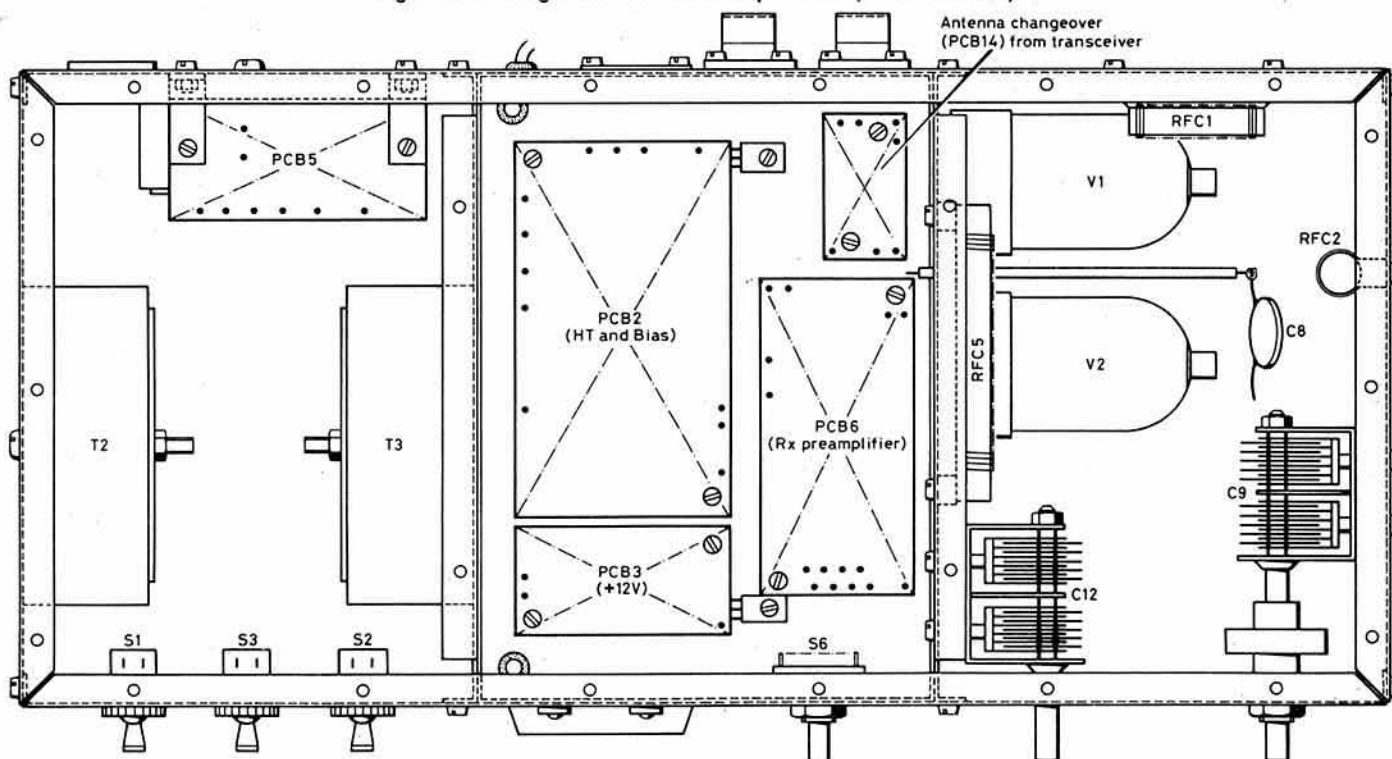
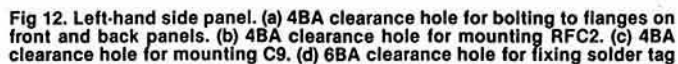
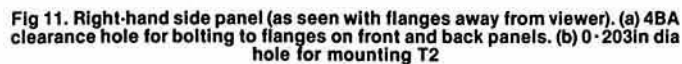
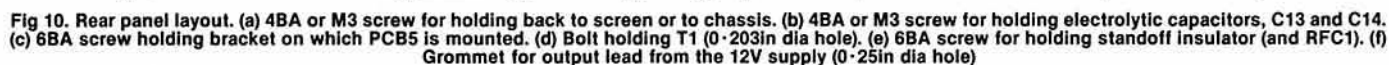
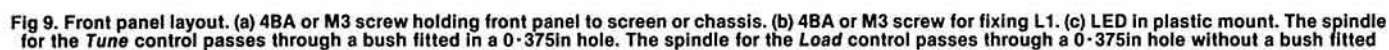


Fig 8. View of linear amplifier unit from the underside (with base removed)



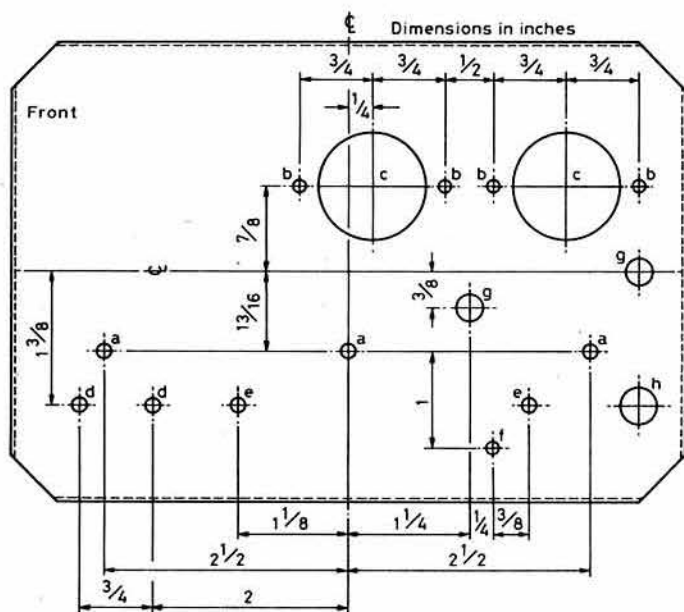


Fig 13. Left-hand screen (with flanges away from viewer). (a) 4BA clearance hole for bolting to chassis. (b) 6BA clearance hole for fixing valveholder. (c) 1.125in dia hole for valveholder. (d) 4BA clearance hole for mounting C12. (e) 4BA clearance hole for mounting RFC5. (f) 6BA clearance hole for fixing earth tag. (g) 0.25in dia hole for grommet. (h) 0.375in dia hole for grommet

tapping screws; and to spray the cabinet with aerosol car paint. The legends can then be put on the front and rear panels, using Letraset stencils and a fibre-tip pen. Finally the cabinet can be given several protective coats of polyurethane varnish.

Fitting the components

The recommended procedure is to concentrate initially on fitting all the components other than printed-circuit boards.

The TUNE capacitor C9 is mounted using nylon 4BA screws and 0.25in high plastic spacers cut from an old ballpoint pen. An insulated flexible coupler must be used to isolate the rotor from the metal spindle which protrudes through the front panel. A suitable bush for the front panel can be salvaged from an old volume control.

The outer rotor plates of this capacitor will be found to be divided into segments which will have been bent by the manufacturer to give accurate tracking. We are more concerned in having an adequate air gap, and any segments which have been bent inwards should be carefully bent back.

The LOAD capacitor C12 is mounted using metal 4BA screws. Care must be taken to ensure that these screws do not short to the stator assembly. The spindle of the capacitor protrudes through the panel without any bush being fitted.

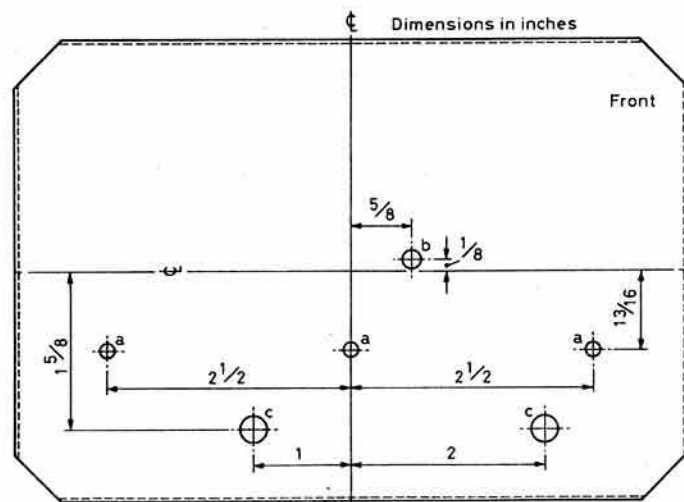


Fig 14. Right-hand screen (with flanges away from viewer). (a) 4BA clearance hole for bolting to chassis. (b) 0.203in dia hole for mounting T3. (c) 0.25in dia hole for grommet

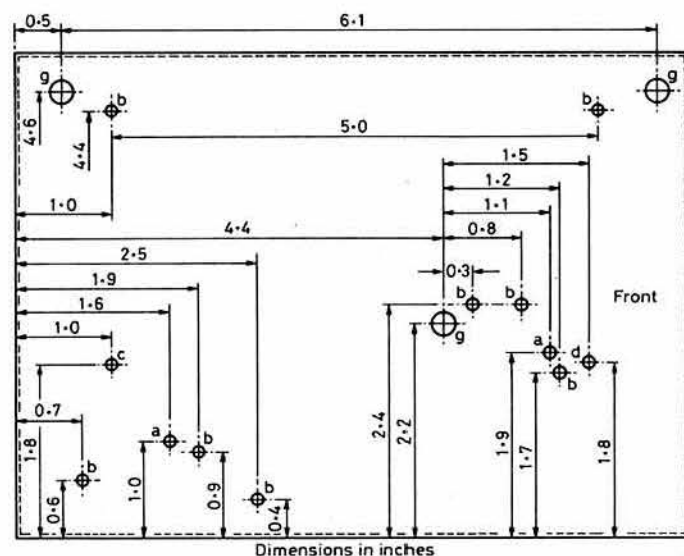


Fig 15. Top view of chassis (flanges underneath). (a) 6BA clearance hole for fixing pillar to top of chassis. (b) 6BA clearance hole for fixing pillar to underside of chassis. (c) 6BA clearance hole for clamping TR201 to chassis. (d) 6BA clearance hole for clamping IC301 to chassis. (e) 0.25in dia hole for grommet

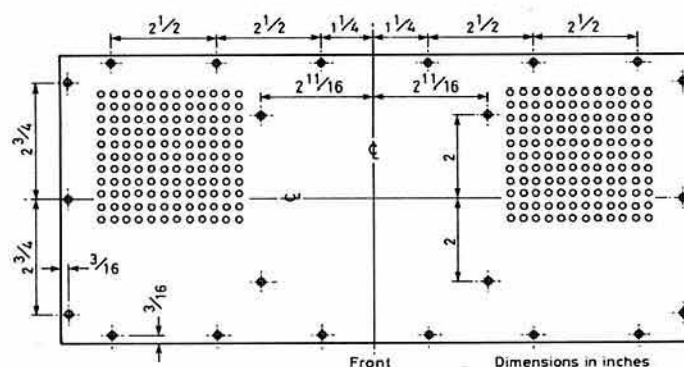


Fig 16. Lid and base. The two blocks of holes are for ventilation. The remainder are for fixing. The base will need four additional holes for fitting plastic feet

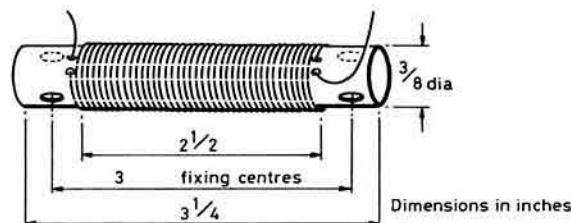


Fig 17. Construction of RFC2 and RFC5. The former is a 0.375in dia plastic tube (eg the barrel of a Pentel ball pen). The winding consists of 28swg enamelled wire close wound over 2.5in

RFC2 and RFC5 are constructed as shown in Fig 17 and mounted on 0.25in high plastic spacers. Self-tapping screws can be used, or the holes in the former can be tapped for M3 or 4BA screws. The upper end of RFC2 will need some kind of solder lug for the connections to RFC2, RFC3 and C7. This lug need be nothing more sophisticated than a short length of tinned copper wire knotted around a hole in the former.

RFC1 is wound on a 0.25in diameter plastic former, 1.5in long, cut from an old ballpoint pen, to which two end-leads of 22swg tinned copper wire have been fixed. The former is filled with 36swg enamelled wire, close wound, and the choke suspended between two stand-off insulators (or small pieces of pcb material fixed onto metal pillars). Under the base of each stand-off there should be a solder tag for earthing the decoupling capacitors.

L1 is constructed as shown in Fig 18. Each end of the winding is secured by threading it through two adjacent 1.5mm holes. Before cementing the turns down it is advisable to fix the lead-out wires (22swg tinned wire is suitable) to the indicated tapping points on the coil. The turns can then be

Components list

PRINTED CIRCUIT BOARD 1

R101	3.3kΩ 1W
R102	1kΩ 0.25W
C101, 103	120pF silvered mica
C102	150pF silvered mica
C104	47pF silvered mica
C105, 106	22pF silvered mica
C107	100-500pF compression trimmer (Maplin)
C108	330pF polystyrene 160V wkg
C109	10nF disc 500V wkg
L101-108	Wound on type 722/2 former (20.5 by 4.8mm dia) with type 4 (4mm) dust core (Maplin). See Table 1 for winding details.
T101	Wound on Siemens A0004X030 twin-hole bead (Electrovalue)

PRINTED CIRCUIT BOARD 2

R201	2.2kΩ 3W
R202	3.3kΩ 3W
R203	22kΩ 3W
R204	220kΩ 1W
R205	330Ω 0.25W
R206	15kΩ 0.25W
R207, 208	33kΩ 0.25W
C201	22μF 450V axial electrolytic
C202	0.22μF 250V ac wkg (eg interference suppression capacitor from Maplin)
C203, 204	100μF 100V axial electrolytic
D201-209	IN4007
D210	200V 1.3W zener
D211	IN4002
D212	47V 400mW zener
TR201	MJE340
FS201	50mA 20mm (and two fuse clips)

PRINTED CIRCUIT BOARD 3

C301	2,200μF 25V axial electrolytic
C302	0.1μF 50V disc ceramic
BR301	W005 bridge rectifier
IC301	7812 (12V 1A) voltage regulator

PRINTED CIRCUIT BOARD 4

R401	2.2Ω 0.5W
R402, 403	Chosen to have total value of (6, 600Ω-meter resistance) 0.25W

PRINTED CIRCUIT BOARD 5

R501	Mains transient suppressor (Maplin, Electrovalue)
FS501, 502	20mm, 500mA antisurge (and four fuse clips)

PRINTED CIRCUIT BOARD 6

R601, 607	22kΩ 0.25W
R602	220Ω 0.25W
R603	470Ω 0.25W
R604, 610	3.3kΩ 0.25W
R605, 608, 609	100Ω 0.25W
R606	4.7kΩ 0.25W
C601, 613	100pF sub-min ceramic plate
C602, 605, 606, 608, 610	10pF sub min ceramic plate
C603, 604, 607, 609	2-22pF miniature film dielectric trimmer (Maplin, Electrovalue)
C611, 612, 614, 615, 616	10nF mylar or sub min disc ceramic
D601	5.1V 400mW zener
D602	BA244

D603	2.7V 400mW zener
TR601	BC558C
TR602	40673
L601-604	Wound on type 722/2 former (20.5 by 4.8mm dia) with type 4 (4mm) iron dust core (Maplin). See Table 1 for winding details.
T601, 602	Wound on Siemens A0007X030 twin-hole bead

PRINTED CIRCUIT BOARD 7

R701	1.5Ω 7W
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COMPONENTS NOT ON PRINTED CIRCUIT BOARDS

R1, 2	10Ω 1W
R3, 4	220kΩ 1W
C1, 2, 4, 5	4.7nF 1kV disc ceramic
C3, 6	10nF 500V disc ceramic
C7	1.5nF high-voltage disc*
C8	5pF high-voltage disc*
C9, 12	365 + 365pF Jackson type O two-gang
C10	180pF high-voltage disc*
C11	1,000pF silvered mica
C13, 14	220μF 450V can type electrolytic**
T1	Toroidal, primary 240V, secondary 15 + 15V. ILP Electronics type 12013
T2	Toroidal, primary 240V, secondary 240V 0.2A. ILP Electronics type 22030
T3	Toroidal, primary 220V, secondary 240V 0.2A. ILP Electronics type 21030. (Note that T2 and T3 are not identical)
V1, 2	6146B
RFC1	1.5in length of 0.25in diameter former close wound with 36swg enamelled wire. See text
RFC2, 5	See Fig 17
RFC3, 4	7t 24swg enam wire wound onto R1, R2
L1	See Fig 18
M1	100μA meter approx 45 by 45mm
LED1	Standard 5mm red L.E.D
LED2	High brightness 5mm red L.E.D (eg Electrovalue cat CQV51J)
S1	250V 2A dpst toggle switch
S2, 3	250V 2A spst toggle switch
S4, 6	Rotary switch single-pole 12W
S5	Maka-Switch shaft assembly + two one-pole 12W bbb wafers (Maplin). See text
Misc	Octal valveholders (2) Valve anode caps or 0.375in Terry clips (2)

*These should be at least 2.5kV wkg. They can be obtained from old tv sets or purchased quite cheaply from dealers selling tv spares. For example, East Cornwall Electronics, 119 High Street, Wem, Shropshire, can supply 1.5nF 3kV (for C7), 10pF 8kV (two in series for C8) and 180pF 8kV (for C10).
**Also obtainable from dealers in tv spares; eg Sendz Components, 63 Bishopsteignton, Shoburyness, Essex, and Post a Part Electronics, 236 Furtherwick Road, Canvey Island, Essex.

Table 1. Details of coils L102-108 and L601-604

Coil	Turns	SWG	μH approx	Coil	Turns	SWG	μH approx
L101	56	40	13	L601	85	40	20
L102	27	32	3	L602	56	36	9
L103	23	28	1.9	L603	35	36	5.5
L104	17	28	1.4	L604	26	32	2.9
L105	18	24	1.0				
L106	14	24	0.8				
L107	13	24	0.75				
L108	10	24	0.6				

All coils are close wound with enamelled wire.

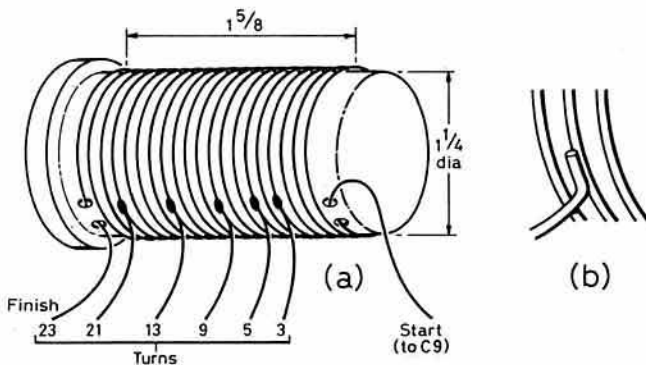


Fig 18. (a) Construction of L1. The former is a 1.25in dia plastic container. The coil is wound with 20swg enamelled wire and spread over 1.625in. (b) Closeup showing how the leadout wire is positioned at a tapping point

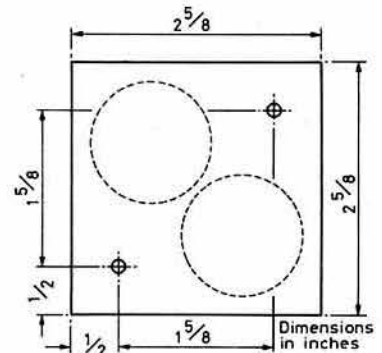


Fig 19. Board for mounting C13 and C14, viewed from the non-coppered side.

spaced out fairly evenly and two lines of polystyrene cement applied, each running the length of the coil, 180° apart. When the cement has become stiff and tacky, the turns can be moved a little, as necessary, to set them to their final positions, and two or three more lines of cement applied. The aim should be to have the windings adequately secured but with as little cement as is practicable.

Before assembling S5 it is recommended that the superfluous contacts be removed from each of the wafers. This can be done by carefully drilling out the rivets.

The two valveholders are fitted so that the valve spigots point away from each other. A solder tag should be fitted under each fixing nut.

The large electrolytic capacitors C13 and C14 need to have their cans insulated. This can be done by wrapping about two turns of card around each, holding the card with two bands of adhesive tape. The capacitors are

fixed onto a piece of printed circuit board such as that in Fig 19, which is then bolted to the back panel. The bases of the capacitor cans and the non-coppered side of the board should be cleaned and roughened, using fairly coarse sandpaper, and the capacitor bases glued to the board using Araldite. It is advisable to bind the two capacitors together using another piece of adhesive tape.

TO BE CONTINUED

Next month, Part 2 will give details of the printed circuit boards and will deal with the commissioning and operation of the unit. It will also describe the modifications necessary to include 1.8MHz operation.

A succeeding article will describe several enhancements which can be made to the transceiver unit.

Gamma matching towers and masts at lower frequencies

V C LEAR, G3TKN*

Introduction

Some years ago I erected a three element hf beam on a tower. However, at the same time I still wanted a useful dx antenna for the lower frequencies, so I decided to gamma feed the tower, and so use it as a top-loaded vertical with the beam acting as the top loading.

An advantage of this method of feed is that the base of the tower does not need to be insulated from ground.

In this article, I have tried to outline the procedures I have used in gamma matching my own tower, so that the general principles may be applied to other installations.

Theory

Before proceeding, it is worth looking at the effect of mounting a beam or quad on a tower.

I have a Hygain TH3 Mk3, three element hf triband beam, mounted on a model P60 Versatower, which can be varied in height between 30ft (9m) and 60ft (18m). The TH3 has a 14ft (4.2m) boom, and elements in the region of 27ft (8.1m). The beam acts as a fairly large capacity hat when mounted on the tower, and lowers the natural resonant frequency of the tower.

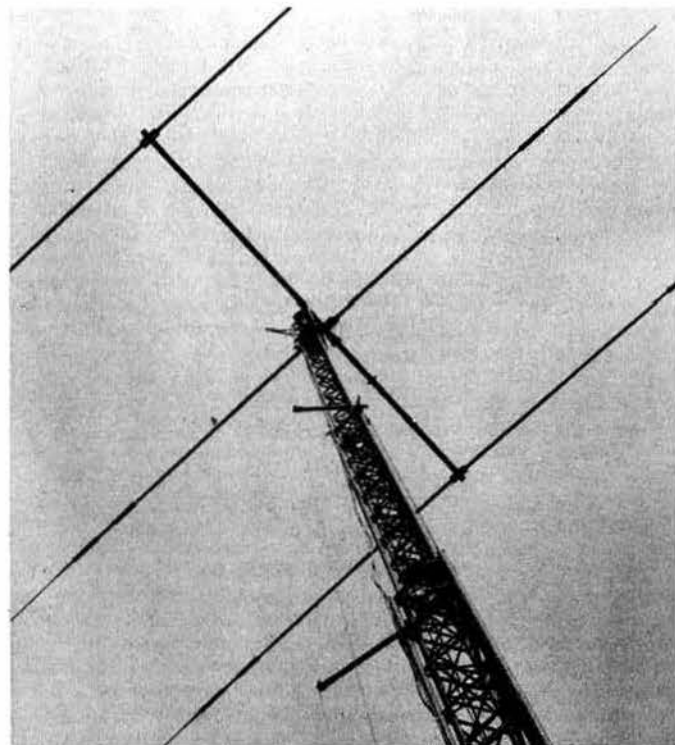


Photo 1. The lower gamma wire is for 7MHz, while the upper one, which is connected to the top of the second section of the tower, is for 3.5MHz. The tower is set at 45ft

If a quad is used in place of a beam, the top loading effect is likely to be less than the all-aluminium tribander because the only part of the quad in electrical contact with the tower would be the boom, assuming the spreaders to be either wood or glass fibre. The driven element would couple into the system by virtue of its feeder, but it is unlikely that the parasitic reflector loop would offer any significant loading.

However, the quad will still give useful top loading. In previous experiments, I found a 21MHz quad lowered the resonant frequency of a 28ft (8.4m) mast from 8.3 to 5.2MHz, thus having the same effect as increasing the mast height by 17ft (5.1m). Despite its small size, this antenna gave very good results on both 7 and 3.5MHz when gamma matched for those bands.

Although it might be of interest to know the natural resonant frequency of a tower plus beam, it is by no means essential, as the structure is tuned to resonance by the combination of the gamma wire and tuning capacitor. As an example, I found that with my tower set at 45ft (13.5m), gamma wire connected 32ft (9.6m) from the base to the top of the second section, and 200pF variable capacitor in series with the gamma wire, the whole antenna could be tuned between 2.5MHz to 6MHz. With the aid of a noise bridge, I measured the resistive impedance to be 40Ω at 3.5MHz.

As a general rule, the electrical height of the whole structure should be no greater than five-eighths of a wavelength at the highest frequency to be used, otherwise high-angle lobes are likely to appear in the radiation pattern.



Vincent Lear became interested in radio while still at school, and obtained his licence, at the age of 15, in August 1964. His main interests have been cw dxing on the lower frequency bands, and experimenting with antennas.

He is head of careers guidance, and also teaches mathematics, in a large comprehensive school. He has also lived and worked in Australia, holding the call VK2EAO.

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A LINEAR AMPLIFIER UNIT FOR THE HF BAND TRANSCEIVER

Lorin Knight,
MIEE, G2DXK *

(Part 2)

Printed-circuit boards

All of these are made from single-sided copper-clad glass-fibre board. Recommendations for making boards were given in the original transceiver article (*Rad Com* August 1984).

Fig 20 shows the etching pattern for the transmitter drive module PCB1, and Fig 21 shows how the components are mounted. After winding T101 it is advisable to check that the insulation on the wire has not been damaged, ie that the resistance between each winding and the other, and of each to the ferrite bead, is not less than 10M Ω . After having confirmed that this is so, it is advisable to run a few drops of polystyrene cement into the bead to prevent the wires moving about. C108 is soldered to the tags on the trimmer capacitor C107, and the leads then taken through and soldered to the underside of the pcb.

4.3 x 1.3in

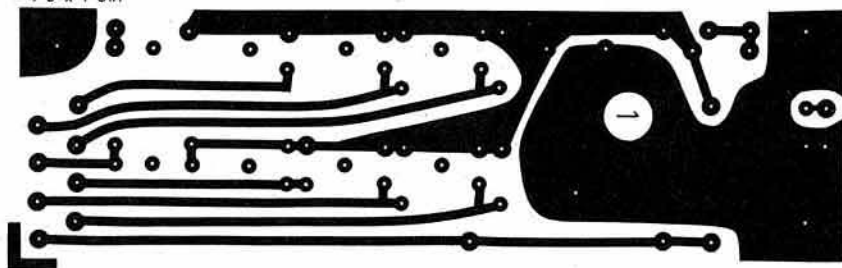


Fig 20. Etching pattern for transmitter drive module PCB1

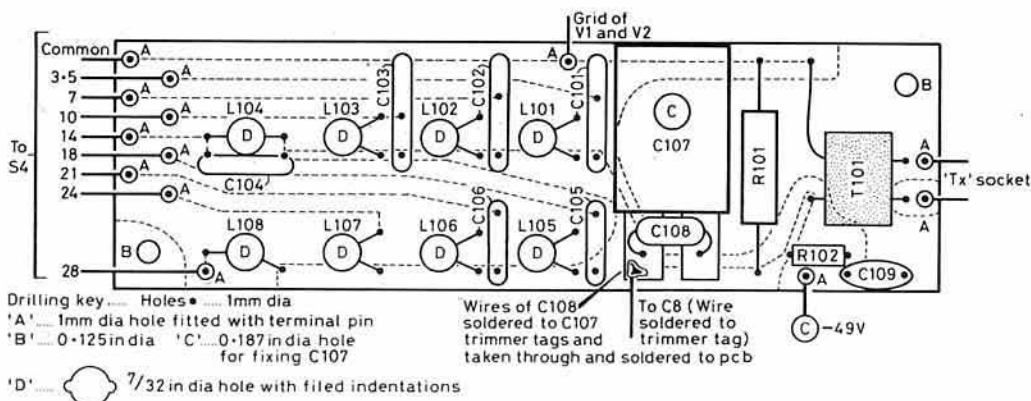


Fig 21. Drilling and assembly of PCB1

The coils L1 to L8 are wound as indicated in Table 1, and the windings are held in place with polystyrene cement. A 0.218in drill is used for the mounting holes, but these need to have small indentations filed into them before the coils can be fitted. Araldite is used to cement the coils to the board.

Fig 22 gives the etching pattern for the ht pcb PCB2, and Fig 23 gives the assembly details. The transistor TR201 is mounted with its wires coming up through the board from the coppered side, the transistor being positioned so that it matches up with the fixing hole in the chassis. The two capacitors C203 and C204 are mounted one above the other.

Figs 24 and 25 give details of the 12V supply module PCB3. The voltage regulator IC301 has its wires coming upwards through the fixing holes and it will be bolted to the chassis.

Figs 26 and 27 give details of the meter-shunt module PCB4. The position of the two mounting holes may have to be changed to suit the particular meter being used.

Figs 28 and 29 give details of the fuse panel PCB5. This board is mounted on two brackets as shown in Fig 30.

Figs 31 and 32 give details of the receiver preamplifier board PCB6. T601 and T602 are wound as indicated in Fig 4, and, after an ohmmeter check to confirm that there has been no insulation damage, should receive a few drops of polystyrene cement.

Fig 33 gives details of the little board PCB7, which holds the heater dropper resistor.

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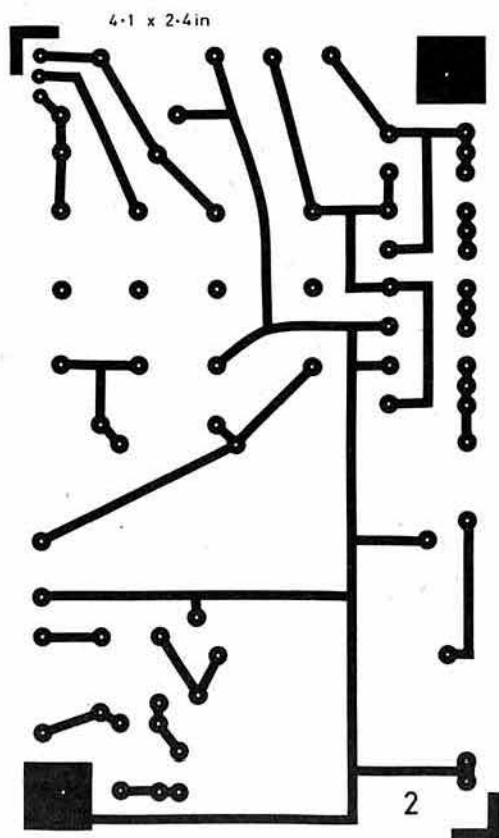


Fig 22. Etching pattern for ht module PCB2

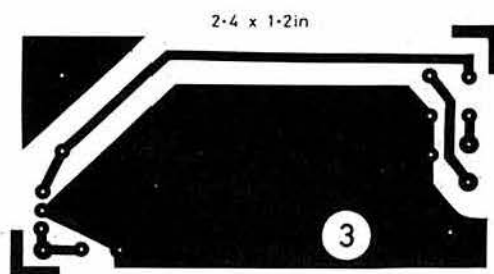


Fig 24. Etching pattern for 12V supply module PCB3

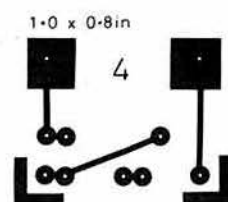


Fig 26. Etching pattern for meter shunt module PCB4

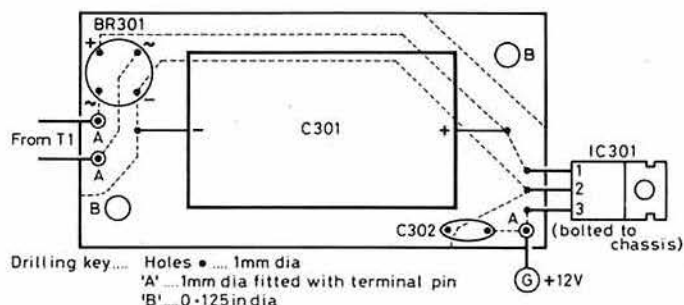


Fig 25. Drilling and assembly of PCB3

Wiring and commissioning the power supplies

It is recommended that the wiring and commissioning starts with the power supplies. Thus PCB2, PCB3, PCB5 and PCB7 should be fitted and all the power supply wiring done, including that to LED2. At this stage, however, nothing should be connected to the outputs, except that the 12·6V supply can be wired up to the valve holders. The heater decoupling capacitors C3 and C6 should be soldered directly from the valveholder pins to adjacent earth tags.

Note that TR201 on PCB2 needs to be clamped to the chassis using a set of insulating washers. No such washers are required for bolting IC301 (on PCB3) to the chassis.

In my prototype the 12V supply to the transceiver unit is taken via an insulated screened lead, which leaves the linear amplifier unit through the grommet at the back and then plugged into the power socket on the transceiver unit. It would be possible, if the constructor so desired, to take the 12V supply via the two six-way DIN connectors.

Because the electrolytic capacitors C13 and C14 will probably have been lying on the shelf for a long time, it is advisable not to bring them up to full voltage too suddenly at first. Thus for the initial test of the ht supply, it is recommended that a 1W resistor of around 1kΩ be soldered across the contacts of the ht on/off switch S2. With the ht switched to LOW and OFF, switch on the mains. The ht at the positive tag of C13 will then rise to around 300V. Let it stand there for 1min or so and then switch the ht to HIGH. The ht will then rise to around 600V. After letting it stand there for 1min or so, switch the ht to ON (ie shorting out the 1kΩ resistor), which will bring the ht up to around 780V. (Later, when the valves are fitted, this voltage will fall to around 670-730V, depending on the current being taken.)

Check that there is +200V at the output of the 200V supply, -49V at the output of the bias supply, and +12V at the output of PCB3.

Don't forget to remove the 1kΩ resistor after the above tests!

Warning

Whenever working with lid and base removed and the mains connected, it is important to remember that there are high voltages present and to exercise the necessary vigilance. Some of the danger can be removed by covering PCB5, S1, S2, S3 and the input connections to PCB2 with a piece of card, 7 by 6in, held in place with masking tape.

Furthermore it should always be remembered that the ht reservoir capacitors C13 and C14 will not discharge immediately on switching off. To be on the safe side, it is advisable not to touch the ht—or the valve anodes—for 2min or so.

Wiring and commissioning the linear amplifier

The linear amplifier can now be wired up, starting with the valveholders. All the earth connections to the valves should be taken direct to solder tags under the fixing nuts of the valveholders. The screen decoupling capacitors C4 and C5 should be connected direct from the valveholder to adjacent earth tags.

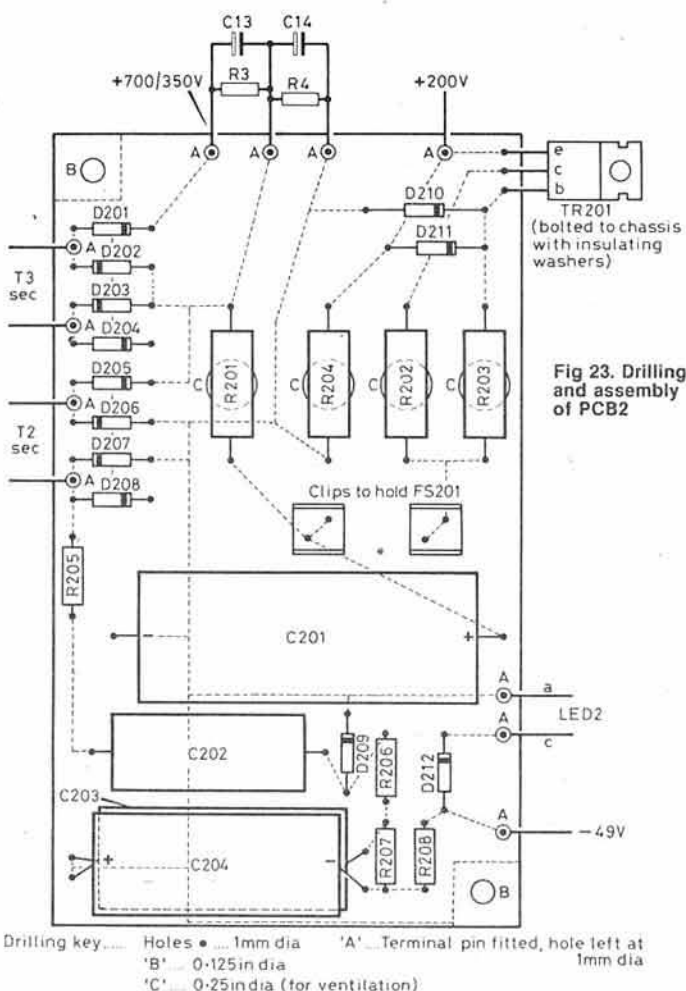


Fig 23. Drilling and assembly of PCB2

PCB1 should now be fitted and connected up. Ideally the connections to the TX PREAMP socket should be made with 50Ω coaxial cable, but a simple twisted pair has been found to be quite adequate.

The connection from C8 to PCB1 needs a special mention. Underneath the valveholders, and centrally between them, there should be a grommetted hole. Wedge or cement into this grommet a 4in length of rigid insulated wire which has had the insulation stripped away for 0.19in at each end (see Fig 8). A suitable wire can be extracted from a scrap piece of 2.5mm² house-wiring cable. One end of the wire is connected to the non-earthed tag of the compression trimmer C107 on PCB1. C8 is strung between the other end of the wire and the rear stator connection on the TUNE capacitor C9. Also connected to this stator connection is the "start" end of L1. If the wire from L1 is bared, the capacitors C7 and C10 can be soldered directly to this wire rather than have to go all the way to C9.

The other end of C7, together with chokes RFC3 and RFC4, are soldered to the lug at the end of RFC2. RFC3 and RFC4 are fixed directly to the anode clips.

The front stator of the TUNE capacitor C9 is connected to an earth tag just above the capacitor (hole "d" in Fig 12). C11 is taken direct from the switch to the LOAD capacitor C12, where it is soldered direct to the corner of the frame. RFC1 is connected to the two standoff insulators on the back panel. The decoupling capacitors C1 and C2 are earthed to the solder tags at the base of the standoffs.

The output from the pi network is taken via 50Ω coaxial cable. The inner conductor is connected to the lower rear stator terminal on C12, and the outer to an earth tag bolted to the chassis (hole "f" in Fig 13). The cable is run along inside the flange on the aluminium screen and taken through the grommet at the rear. As a temporary measure it should be taken direct to the ANTENNA socket, but later, when the antenna changeover module has been fitted, it will have to go to that.

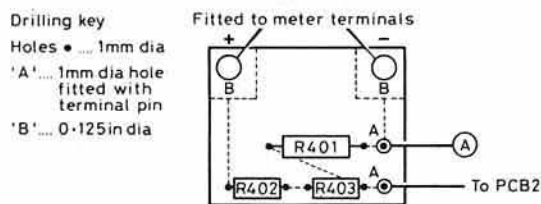


Fig 27. Drilling and assembly of PCB4

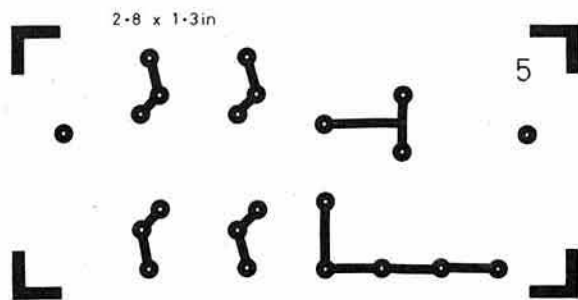


Fig 28. Etching pattern for fuse panel, PCB5

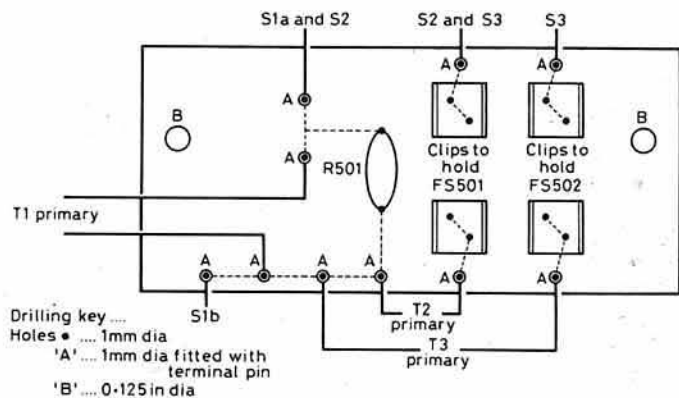


Fig 29. Drilling and assembly of PCB5

Testing of the linear amplifier can now begin. The essential items which will be required for testing are:

- A 50Ω dummy load capable of withstanding at least 25W.
- An swr meter or some other device which will give a rough indication of the power going into the dummy load.
- A meter capable of reading around 0-10V rf.

The initial testing should be done with the ht switched off. First check that there is 6.3V ac ($\pm 0.2V$ or so) across each valve heater.

Connect the output of the transceiver to the TX PREAMP socket on the linear amplifier unit. Set the DRIVE switch to the appropriate band. Switch the transceiver to cw, clamp the key down and turn the TX OUTPUT control to give an output of about 2V. Clip the rf voltmeter lead to the insulation of the wire going to the valve grids (so as to minimize the loading of the meter on the tuned circuit) and tune the appropriate coil on PCB1 for maximum meter reading. Repeat for the other bands.

Neutralizing the internal anode-to-grid capacitance of the valves should be done next. This can be done on any frequency band, but for an optimum balance it is probably preferable to choose a middle-frequency band such as 7 or 14MHz.

The rf voltmeter is connected to the junction of the two anode chokes R3 and R4, and, with an rf input applied to the linear, but still with no ht applied to the valves, the TUNE and LOAD capacitors are tuned for maximum reading. The compression trimmer C107 is then tuned for minimum meter reading.

The ht can now be switched on and, with no rf input and the ht switch at HIGH, a check made that the valves take a total anode current of around 50mA (17μA on the scale if it has not been re-drawn). Should it be more like 70mA (23μA) it will be advisable to increase the bias voltage by adding a low voltage zener in series with the 47V one. The screen current should be low and thus LED1 should only be very dimly illuminated.

Tuning up the linear amplifier

A continuous tone will be required for tuning up the linear amplifier. The easiest way of obtaining this is to switch to cw and hold down the key but, if available, a two-tone oscillator could be fed into the microphone socket.

With the TX OUTPUT control on the transceiver initially turned up just a little way, adjust the TUNE and LOAD controls for maximum rf into the dummy load. It should be noted that when the LOAD capacitor is set to a higher capacitance than that which gives maximum output, the valves are not fully loaded and the screen current (as indicated by LED2) is considerably higher. In fact the desirable setting is with the capacitor set slightly to the other side of the maximum output position.

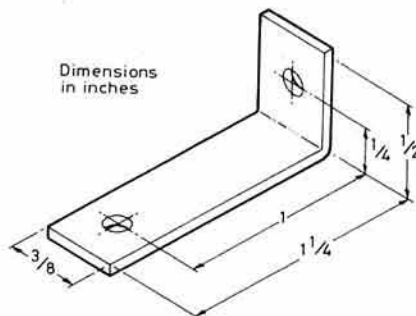


Fig 30. Brackets for fixing fuse panel PCB5. Material: 18swg aluminium or as available. Holes are 6BA clearance

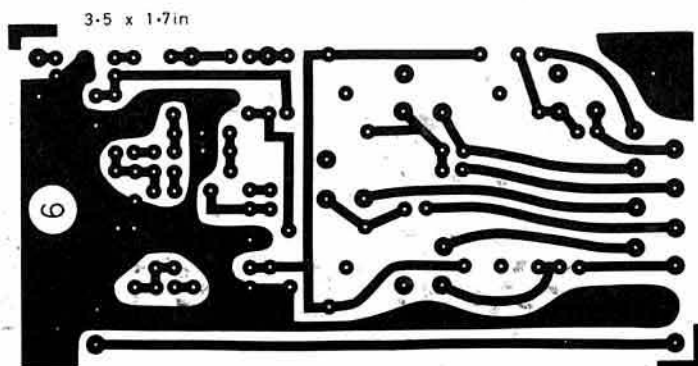


Fig 31. Etching pattern for receiver preamplifier module PCB6

Fig 32. Drilling and assembly of PCB6

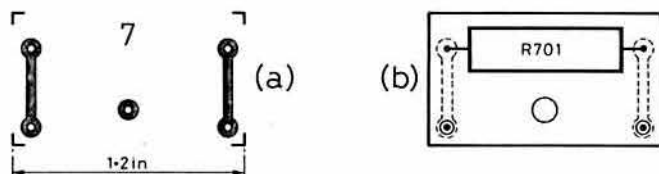
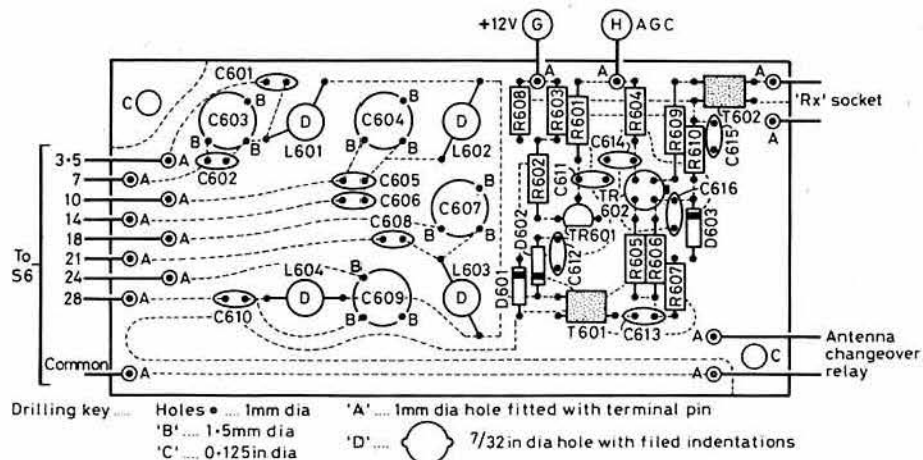


Fig 33. Board (PCB7) for mounting heater dropper resistor. (a) Etching. (b) Assembly

Thus in order to avoid overheating in the valves (and possible resultant damage), as well as undesirable waveform distortion, it is advised that: (a) After the LOAD control setting for maximum output has been found, the control is turned slightly anticlockwise (ie to a slightly lower capacitance). (b) The drive to the valves is kept below the point at which grid current occurs (shown by a brightening of LED2). Driving beyond this point will also give increased screen current and increased distortion. (c) Full drive should not be applied to the valves if no output load is connected. This will also give high screen current.

The screen current can be monitored at all times by observing LED1. When operating at full power with a single continuous tone, the total screen current for both valves should ideally be around 12mA, but it should never be greatly in excess of this figure. In order to obtain some idea of what a current of 12mA means in terms of the brightness of LED1 relative to that of LED2, a check can be made by putting a voltmeter across R202 on the power supply board. A reading of 40V will correspond to a screen current of 12mA. The total anode current, when the linear is fully driven with a single steady tone, will be around 220mA (or 75μA if the meter scale has not been redrawn).

Commissioning the receiver preamplifier

Having commissioned the power supply and the linear amplifier itself, the remaining tasks within the linear amplifier unit consist of (a) fitting the antenna changeover (A) board (PCB14) from the transceiver unit, (b) fitting the receiver preamplifier PCB6, and (c) wiring them up.

Then, in the transceiver unit, the output of the transmitter preamplifier needs to be connected directly to the TX socket, and the RX socket needs to be connected to the antenna changeover (B) board (PCB13). The DIN socket also needs to be connected up; pin 3 to the agc line, pin 1 to the c/o relay energizing line (L), and pin 2 to earth.

A lead will have to be made up to interconnect the DIN socket on the transceiver with that on the linear amplifier. The use of a four- or five-way screened lead will leave some capacity for possible additional connections later.

With the two units fully interconnected, the receiver can be tested with its preamplifier. (Connect it to a real antenna now: otherwise the results will be disappointing!) On each band the appropriate tuned circuit on the preamplifier should be tuned for maximum gain. Where two bands share one coil, the coil should be peaked-up first on the band which has a fixed capacitor, and the preset capacitor used for peaking up on the other band.

Modifications to include 1.8MHz

The modifications needed to extend the operation of the linear amplifier unit to include 1.8MHz will be described on the assumption that this is to be provided in addition to all the other bands. Suitable simplifications can be made by the constructor if he does not want an all-band capability.

The most important differences concern the pi network at the output of

the linear amplifier, the revised circuit being shown in Fig 34. The output switch S5 needs to have a third wafer, and the additional components L2 and C17 are required. L2 is wound on a 0.625in diameter former, which is 1.25in long and fitted with reasonably stiff leadout wires so that the coil can be suspended in the wiring.

Adapting the pi network to cater for 1.8MHz introduces some problems because, ideally, C1 and C2 need to have a very large capacitance swing. In order to accommodate the existing capacitors, the working Q of the circuit is arranged to be around eight instead of the more desirable value of 12. This allows C1, with suitable padding capacitance added, to cover the range 1.8 to 2MHz, with just a tiny amount to spare.

(Continued on page 261)

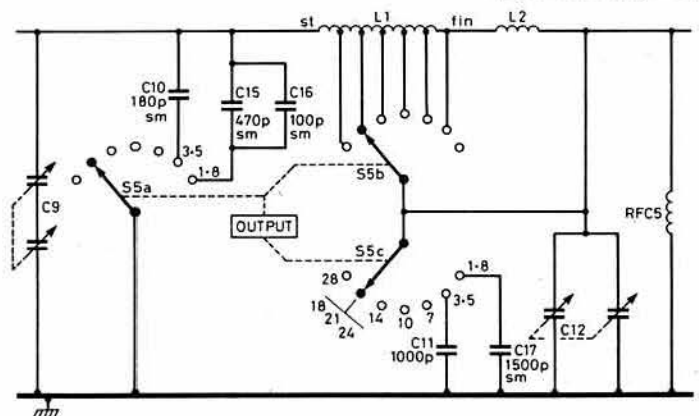


Fig 34. Revised circuit of pi-network to include 1.8MHz band. C15, 470pF; C16, 100pF; C17, 1500pF (all silvered mica). L2, 30t 28swg enamelled wire closewound on 0.625in diameter former. S5 needs an additional wafer. Other components unchanged

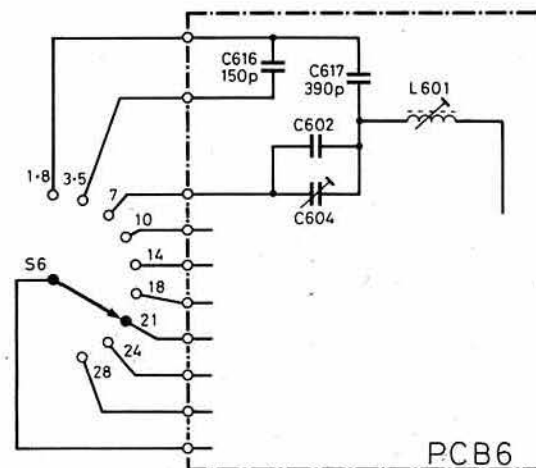


Fig 35. Modifications to receiver preamplifier switching to include 1.8MHz. C616, 150pF; C617, 390pF (both sub-min ceramic plate). Other components unchanged

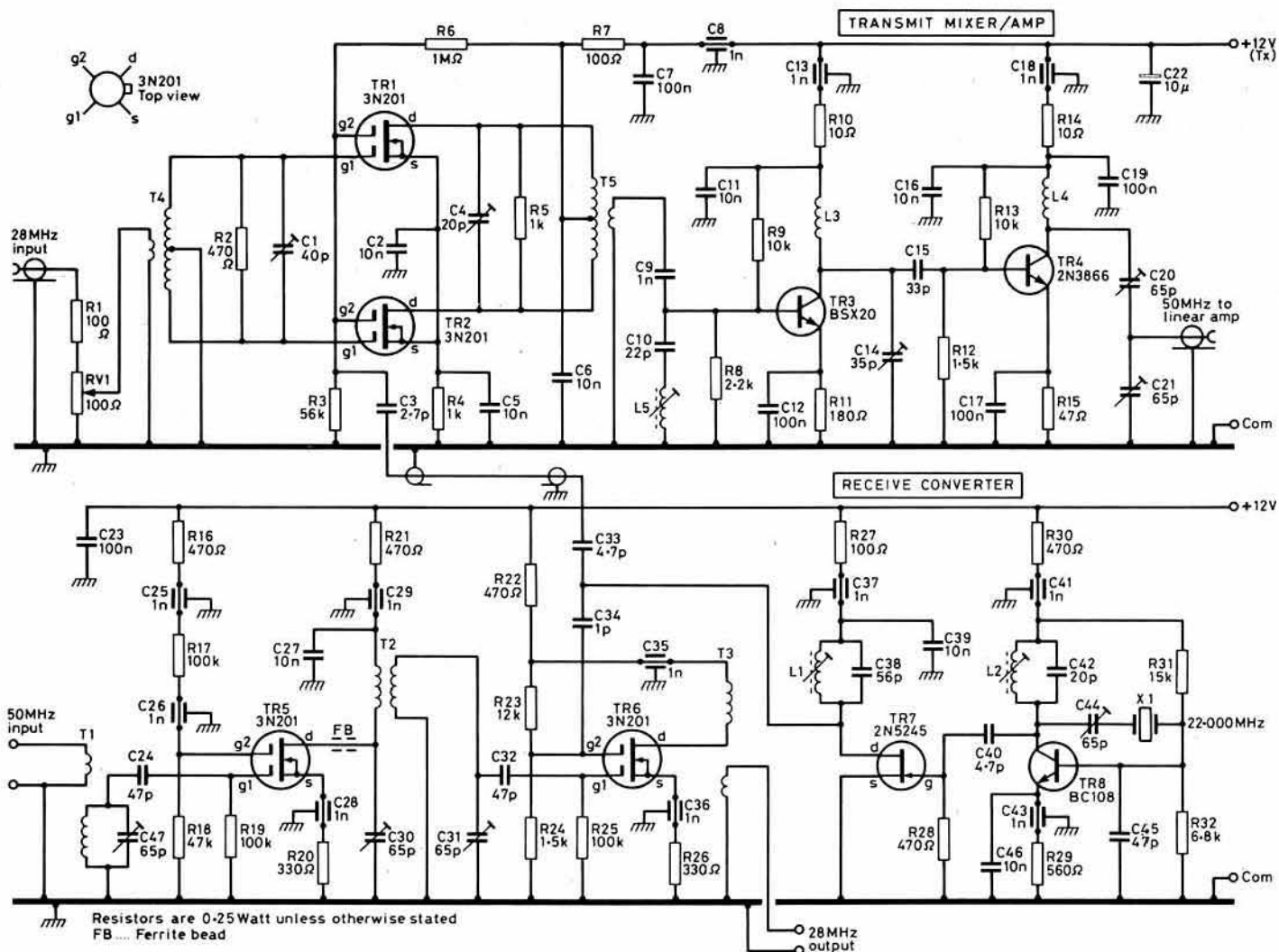


Fig 2. Transmit mixer/amplifier and receive converter circuit diagram

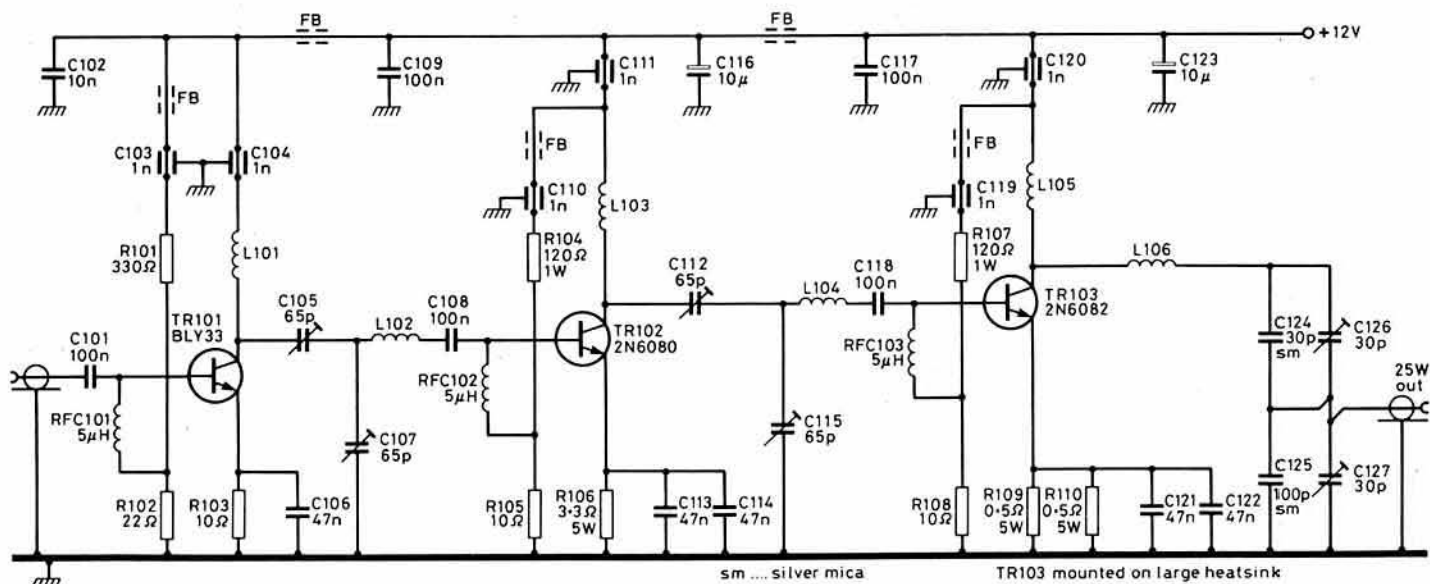


Fig 3. Linear amplifier circuit diagram

required for full output. Therefore, if the converter is to be used with a transceiver, a suitable attenuator should be included in the circuit.

References

- [1] "Dual-gate fet converters for two and four metres", C W Westwood, G3VFD. *Rad Com* October 1969.
 [2] "A 70MHz transistorized transmit/receive converter", D F Harvey, G3XBY, and C S Gare, G3WOS. *Rad Com* February 1977.

Components list

Transmit mixer/amp and receive converter

R1, 7, 25	100Ω
R2, 16, 21, 22, 28, 30	470Ω
R3	56kΩ
R4, 5	1kΩ
R6	1MΩ
R8	2·2kΩ
R9, 13	10kΩ
R10, 14	10Ω
R11	180Ω
R12, 24	1·5kΩ
R15	47Ω
R17, 19, 25	100kΩ
R18	47kΩ
R20, 26	330Ω
R23	12kΩ
R29	560Ω
R31	15kΩ
R32	6·8kΩ
RV1	100Ω

C1	40pF
C2, 5, 6, 11, 16, 18, 27, 39, 46	10nF
C3	2·7pF
C4	10pF
C7, 12, 17, 19, 23, 24	100nF
C8, 9, 13, 25, 26, 28, 29, 35, 36, 37, 41, 43	1nF
C10	22pF
C14	35pF trimmer
C15	33pF
C20, 21, 30, 31, 44	65pF trimmer
C22	10μF
C33, 40	4·7pF
C34	1pF
C38	56pF
C42	20pF

TR1, 2, 5, 6	3N201
TR3	BSX20
TR4	2N3866
TR7	2N5245
TR8	BC108

T1	(Primary 2t 20swg 0·5in id enam copper Secondary 7t 20swg 0·5in id enam copper)
T2	(Primary 7t 20swg 0·5in id enam copper Secondary 7t 20swg 0·5in id enam copper)
T3	(Primary 25t 32swg enam Secondary 2t 26swg pvc covered) Wound on 0·25in former with iron-dust core
T4	(Primary 2t 28swg pvc covered Secondary 8t + 8t 32swg enam) Wound on 0·25in former—no core
T5	(Primary 4t + 4t 26swg enam Secondary 2t 28swg pvc covered) Wound on 0·25in former—no core
L1	12t 24swg enam wound on 0·25in former with iron-dust core
L2	20t 26swg enam wound on 0·25in former with iron-dust core
L3	7t 20swg 0·375in enam copper
L4	7t 20swg 0·375in id enam copper
L5	9t 24swg enam wound on 0·25in former with iron-dust core

LINEAR AMPLIFIER

R101	330Ω
R102	22Ω
R103, 105, 108	10Ω
R104, 107	120Ω 1W
R106	3·3Ω 5W
R109, 110	0·5Ω 5W
C101, 108, 109, 117, 118	100nF
C102	10nF
C103, 104, 110, 111, 119, 120	1nF

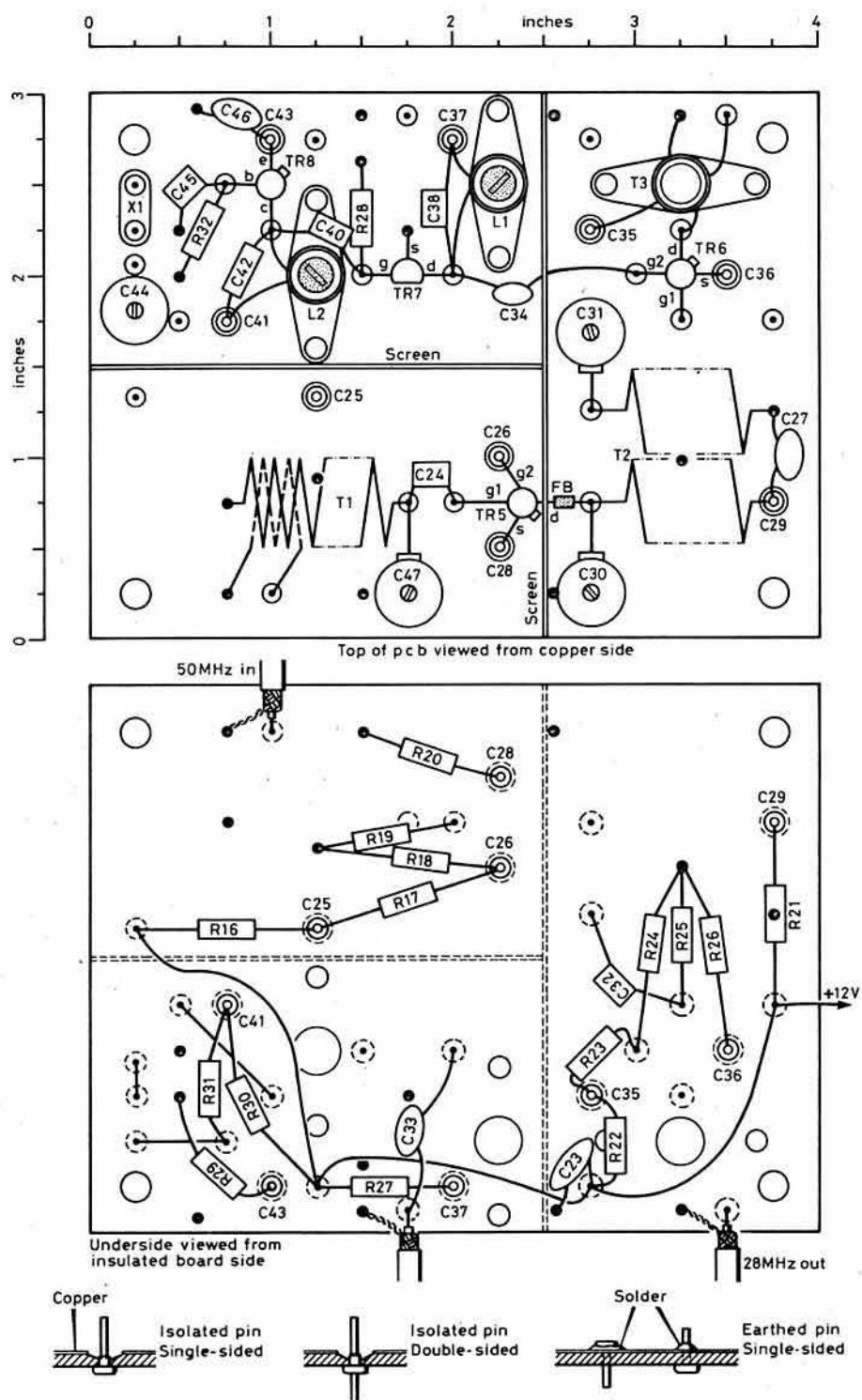


Fig 4. Receive board component layout

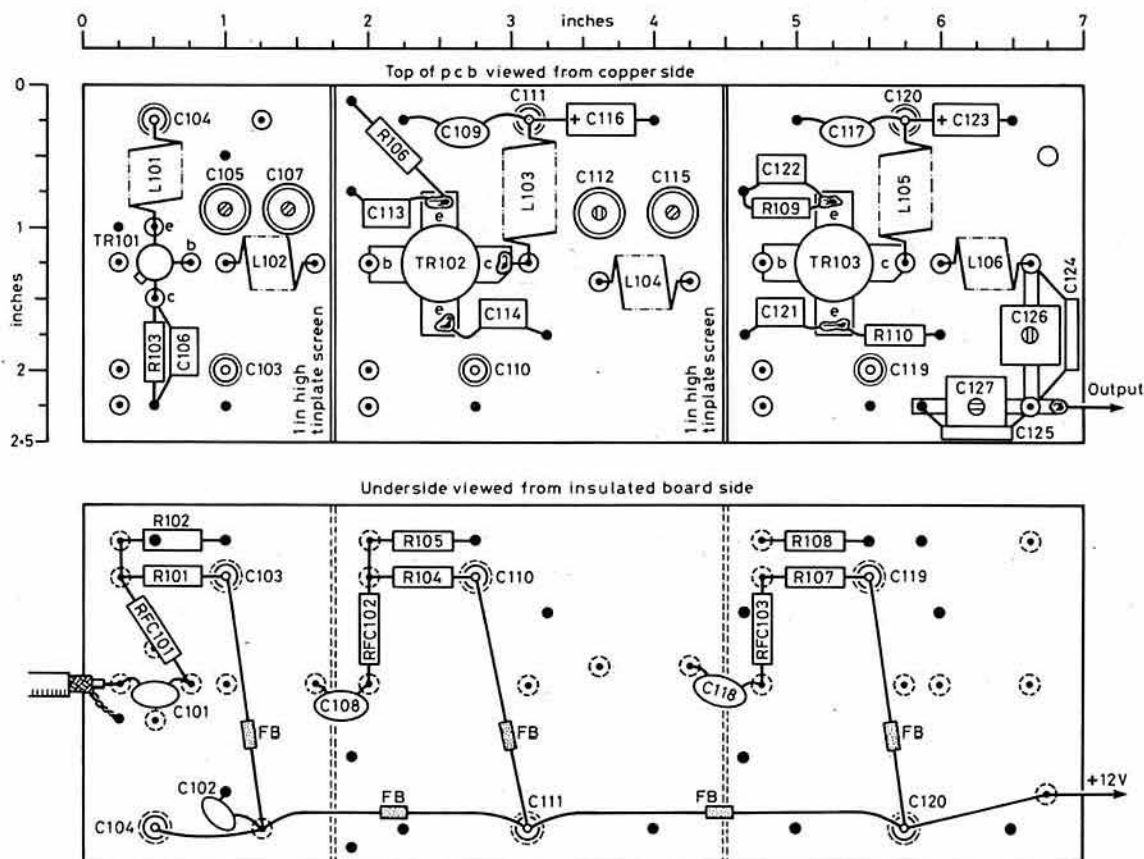


Fig 5. Linear amplifier component layout

C105, 107, 112, 115
C106, 113, 114, 121,
122
C116, 123
C124
C126, 127

65pF trimmer
47nF
10 μ F
30pF sm
30pF trimmer

L101
L102
L103
L104
L105
L106

7t 18swg 0.375in id
5t 18swg 0.375in id
7t 18swg 0.375in id
3t 18swg 0.375in id
8t 18swg 0.375in id
7t 16swg 0.375in id

tinned copper

TR101
TR102
TR103

BLY33
2N6080
2N6082

RFC101, 102, 103
PCB (single-sided)
PCB (double-sided)
Twist drill bits

5 μ h vhf choke R S Stock No 238-255
Pins R S Stock No 433-624
Pins R S Stock No 433-630
1.3mm (0.052in) R S Stock No 549-195

A LINEAR AMPLIFIER UNIT FOR THE HF BAND TRANSCEIVER

(Continued from page 257)

Because of the limited capacitance range of C1, it may be necessary to adjust the inductance of L2 in order to ensure full coverage from 1.8 to 2MHz. Thus the constructor is advised initially to put a few extra turns on L2 and remove turns as found necessary.

The range of the LOAD capacitor C2 is also restricted. However, the precise loading setting is not so important on 1.8MHz, where the linear will not be working at its maximum power capability, and the consequences of this restriction will not be important, provided that the transmitter is working into an essentially resistive 50 Ω load.

Fig 35 shows the changes required to the receiver preamplifier switching. When S6 is switched to 1.8MHz, L601 has a series capacitance of 390pF (C617). When the switch is at 3.5MHz, L601 has a series capacitance of 108pF (C616 and C617 in series). L601 is tuned for maximum gain in the centre of the 3.5MHz band and C603 is tuned for maximum gain in the centre of the 7MHz band. On the 1.8MHz band the circuit should then be on tune.

At the input of the linear amplifier no tuned circuit is necessary for 1.8MHz. The DRIVE switch merely needs to have an extra blank position, which leaves R101 unshunted.

On 1.8MHz the linear amplifier must be kept below its maximum output capability in order to meet the licensing regulations. To assist in this, the ht switch should be kept in the LOW position.

Operation of the linear amplifier

With the ht switch in the OFF position, the DRIVE and OUTPUT switches should be set to the required band. If the antenna does not look like approximately 50 Ω at the shack end of the downlead, an antenna tuning unit will be essential. Even if the antenna does look like 50 Ω , an atu is still useful to provide a little extra attenuation to out-of-band signals.

If an atu is used, it is recommended that the linear first be tuned up with a dummy load. Then, after connecting the linear up to the atu, the latter can be adjusted for minimum swr, and any final adjustments done using the TUNE and LOAD controls.

Throughout the tune-up procedure care should be taken, as outlined earlier, to avoid excess screen current. The valves will tolerate a great deal of mishandling but it is not advisable to tempt providence too far!

When operating, the peak level of the signal will be stabilized by the alc circuitry in the transceiver unit. Thus, once the TX OUTPUT control has been set to the required position, the p.e.p. of the output will be maintained at a constant level.

When operating ssb, the average anode current will be considerably less than with a continuous single tone of the same p.e.p.

Enhancements to the transceiver

This concludes the description of the linear amplifier unit. Next month a complementary article will describe some enhancements which can be made to the transceiver unit itself.